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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H02J 7/00 | A1

(11) International Publication Number: WO 98/43337

(43) International Publication Date: 1 October 1998 (01.10.98)

(21) International Application Number: PCT/IB98/00218

(22) International Filing Date: 23 February 1998 (23.02.98)

(30) Priority Data:
9705870.5 21 March 1997 (21.03.97) GB

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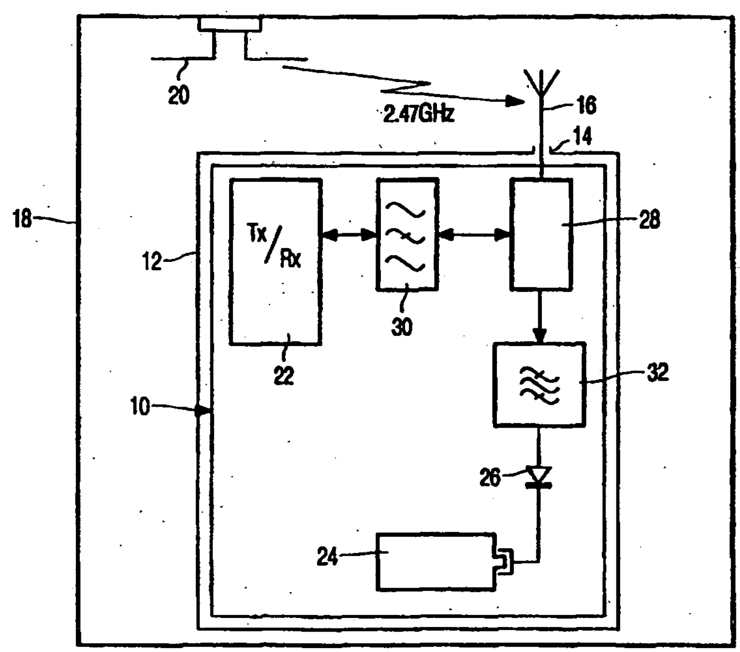
(81) Designated States: CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: CHARGING OF SECONDARY CELLS USING TRANSMITTED MICROWAVE ENERGY

(57) Abstract

A method of charging/recharging a secondary cell (24) by rectifying transmitted microwave energy which may be supplied by an unmodified microwave oven (18) into which it is placed. The secondary cell (24) or an article, such as a portable transceiver (10), containing a secondary cell is protected from the harmful effects of microwave energy using a Faraday cage (12) and an antenna (16) disposed outside the Faraday cage picks up the energy which is rectified using for a Schottky barrier diode (26). Optionally the secondary cell may be disposed outside the oven (18) and the rectified current is supplied from the interior of the oven by way of conductors and/or a suitable connector.



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DESCRIPTION

CHARGING OF SECONDARY CELLS USING TRANSMITTED MICROWAVE ENERGY

Technical Field

The present invention relates to a method of, and apparatus for, charging/recharging secondary cells using transmitted microwave energy.

Background Art

The concept of generating dc power from transmitted radio waves is known from IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-32, No. 9 September 1984 pages 1230 to 1242 "The History of Power Transmission by Radio Waves" by William C. Brown. The article reports that recovering dc power using a half-wave rectifier is an effective, relatively expensive and simple alternative compared to using a full wave rectifier. The rectifiers may be gallium arsenide Schottky - barrier diodes otherwise known as IMPATT devices.

US Patent Specification 5,122,809 discloses a device for generating dc power directly from microwave energy. The device comprises a microstrip resonator having a line length of half a wavelength at the desired frequency. The resonator is split at its centre into 2 separate, aligned portions. A Schottky rectifier interconnects the adjacent ends of the separate portions of the resonator. No practical application is disclosed for the dc power generated.

Charging and/or recharging secondary cells normally requires connecting the cell(s) to a dedicated battery charger which a user does not carry with them. Additionally fast charging of cells normally takes at least 30 to 60 minutes which is not convenient in situations such as patrolling policemen where there is a requirement to be capable of maintaining radio contact whilst out on patrol. Accordingly there is a need to be able to recharge secondary cells very rapidly without requiring a dedicated battery charger.

Disclosure of Invention

According to one aspect of the present invention there is provided a method of charging a secondary cell in which the charging current is derived from transmitted microwave energy.

According to another aspect of the present invention there is provided an apparatus for charging a secondary cell, comprising a source of microwave energy having a chamber and means in the chamber for detecting and rectifying microwave energy emitted by said source and for conducting the rectified energy to a secondary cell.

The source of transmitted microwave energy may be a microwave oven operating at a frequency greater than 2GHz, for example between 2.4 and 2.5 GHz. The detected microwave energy may be rectified and the nominally dc current conducted to the outside of the microwave oven. Alternatively the secondary cell and/or article containing the secondary cell may be placed in the oven chamber. In the latter event, the secondary cell and or article may be protected from the harmful effects of the microwave energy, which effects may result in lossy materials being heated excessively leading to electrical and/or structural damage. Using a Faraday cage is one method by which the secondary cell(s) or article may be protected. The Faraday cage may be formed integrally with the housing of the secondary cell(s) or article or may be separate from and enclose the cell(s) or article.

In order to illustrate the fast recharging achieved by the method in accordance with the present invention, consider for example a typical rechargeable battery having a capacity of substantially 1 amp - hour at 6V, or substantially 22 kJ. A microwave oven which radiates 700W will supply this amount of energy in 30 seconds if the charging process is 100% efficient and 5 minutes if the charging process is 10% efficient. Rechargeable cells which can be recharged as quick as this can now be produced.

Brief Description of Drawings

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is a diagram illustrating a cellular or cordless telephone enclosed in a Faraday cage and placed in a microwave oven,

Figure 2 is a diagram illustrating a secondary cell and battery charging rectifier built into Faraday cage having a microwave antenna on exterior of the Faraday cage,

Figure 3 is a schematic circuit diagram of a charging circuit having overcharging protection, and

Figure 4 is a diagram showing an arrangement in which transmitted microwave energy is rectified inside a microwave oven and the rectified current is used to charge/recharge a secondary cell located outside the oven.

In the drawings, the same reference numerals have been used to indicate corresponding features.

Modes for Carrying Out the Invention

Figure 1 shows a cellular telephone 10 mounted in a Faraday cage 12 which has an opening 14 through which the antenna 16 of the cellular telephone protrudes. The Faraday cage 12 together with the cellular telephone 10 is placed in an unmodified microwave oven 18 having an antenna 20 which radiates microwave energy having a frequency of greater than 2.0 GHz, typically at an approved frequency such as 2.47 GHz in the band between 2.4 and 2.5 GHz.

The cellular telephone 10 includes a transceiver 22 and associated circuitry and is powered by a secondary cell 24, for example a Ni - Cd cell. The secondary cell 24 is rechargeable using the transmitted microwave energy from the antenna 20 which is picked-up by the antenna 16 and conducted to a half - wave rectifier 26, for example a gallium arsenide Schottky - barrier diode. The output from the rectifier 26 is supplied to the secondary cell 24.

In order to prevent microwave energy from reaching the transceiver 22 and transmitted signals from the transceiver being used for charging the cell

24, a high quality diplexer 28 is coupled to the antenna 16. A band stop filter 30 is coupled between a first port of the diplexer 28 and the transceiver 22 and a band pass filter 32, centred on the frequency of the microwave energy (for example 2.47 GHz), is coupled between a second port of the diplexer 28 and the rectifier 26.

If desired the Faraday cage 12 may be integrated with the housing of the cellular telephone 10 so that the entire self contained unit can be placed in the microwave oven.

Figure 2 illustrates an embodiment of a secondary cell 24 which is enclosed in a Faraday cage 12. A rectifier 26 is disposed within the Faraday cage 12 and has its cathode connected to a positive terminal of the cell. The anode of the rectifier 26 is coupled to a first portion 16A of a microstrip antenna 16, a second portion of which is connected to the Faraday cage 12.

The arrangement shown in Figure 2 comprises an integral, self-contained battery unit which can simply be detached from its user apparatus, placed in a microwave oven, irradiated with microwave energy to recharge the secondary cell, and refitted to the user apparatus.

Figure 3 shows an arrangement for protecting the secondary cell 24 from being charged too quickly and/or being overcharged. A positive temperature coefficient (PTC) thermistor 34 is connected in series with the secondary cell 24 and is thermally coupled to the cell 24 in order to sense its increase in temperature as the cell charges up. As the temperature in the secondary cell 24 increases, the resistance of the thermistor increases thus reducing the current flow.

Figure 4 illustrates a variant of the arrangement shown in Figure 1 in which a microstrip resonator 36 having a line length of half a wavelength of the centre frequency to be received is split into two equal length portions 36A and 36B which are electrically interconnected at their adjacent ends by a Schottky-barrier diode. The rectified current generated is conducted by electrical conductors 38, 40 outside the microwave oven 18 where it is used to charge/recharge the secondary cell 24 which may be mounted in situ in a

transceiver housing. If desired a connector 42 may be provided in a wall of the oven 18.

Although the present invention has been described in respect of secondary cells used in telecommunications apparatus it may be applied to an other apparatus which may be adapted to receive transmitted microwave radiation.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of battery charging systems and component parts thereof and which may be used instead of or in addition to features already described herein.

Industrial Applicability

Fast charging/recharging of secondary cells for use in portable equipments such as cellular and cordless telephones.

CLAIMS

1. A method of charging a secondary cell in which the charging current is derived from transmitted microwave energy.

2. A method as claimed in Claim 1, characterised by protecting at least the secondary cell from the harmful effects of microwave radiation whilst the secondary cell is being charged/recharged.

3. A method as claimed in claim 1, characterised in that at least the secondary cell is contained in a Faraday cage and in that an antenna and rectifying means are coupled to the secondary cell.

4. A method as claimed in claim 1, 2 or 3, characterised by converting transmitted microwave energy to the dc current inside a microwave oven and conducting the dc current out of the microwave oven to recharge a secondary cell.

5. A method as claimed in any one of claims 1 to 4, characterised by protecting the secondary cell from being overcharged.

6. An apparatus for charging a secondary cell, comprising a source of microwave energy having a chamber and means in the chamber for detecting and rectifying microwave energy emitted by said source and for conducting the rectified energy to a secondary cell.

7. An apparatus as claimed in claim 6, characterised in that the source of microwave energy includes a chamber having means to radiate the microwave energy.

8. An apparatus as claimed in claim 7, characterised in that

protection means are provided for protecting the secondary cell or an article containing the secondary cell from the harmful effects of microwave radiation whilst being charged/recharged in said chamber.

9. An apparatus as claimed in claim 11, characterised in that the protection means comprises a Faraday cage.

10. An apparatus as claimed in any one of claims 6 to 9, characterised by overcharging protection means for the secondary cell.

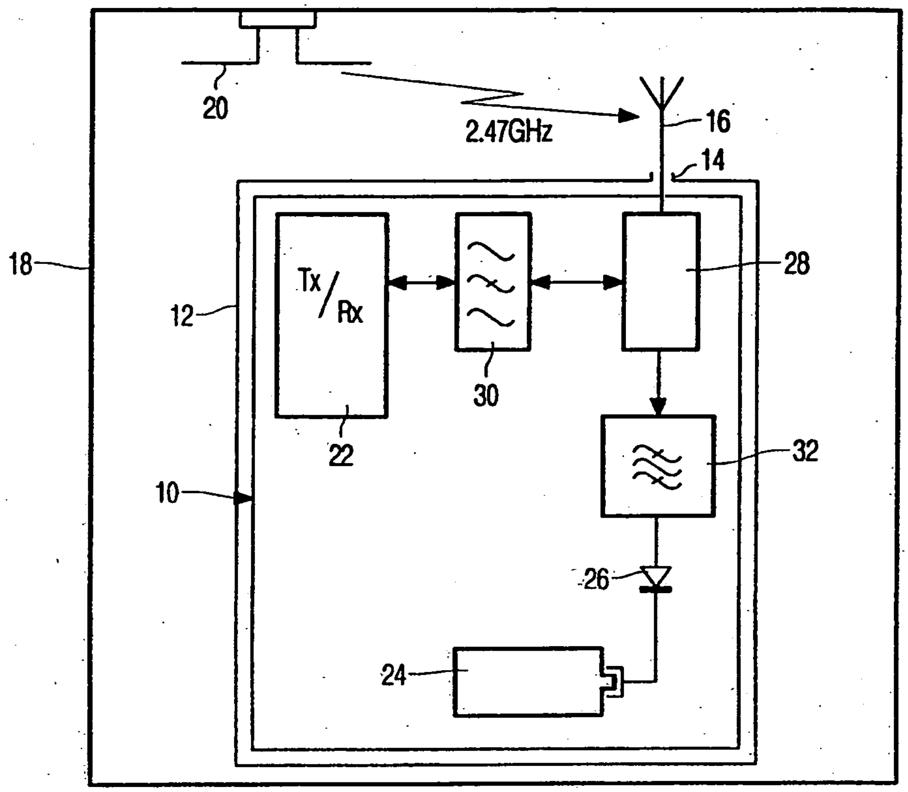

FIG. 1

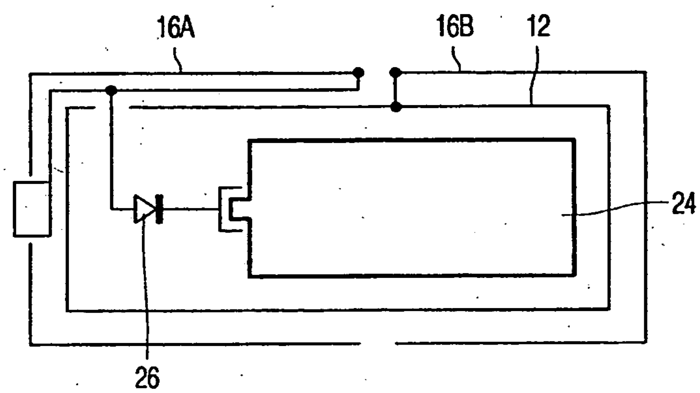

FIG. 2

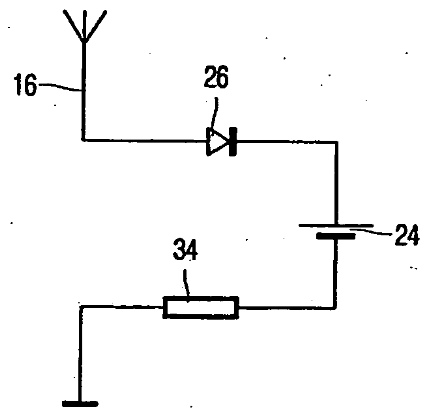

FIG. 3

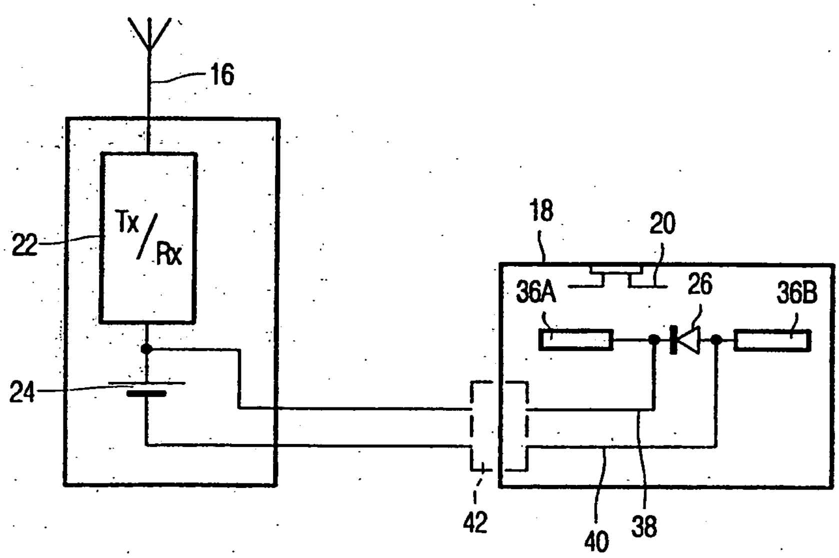

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 98/00218

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02J 7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02J, H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5122809 A (S. HARUYAMA ET AL.), 16 June 1992 (16.06.92), column 1, line 55 - column 2, line 2	1,6,7
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X	US 4918749 A (H. ENTSCHLADEN ET AL.), 17 April 1990 (17.04.90), column 2, line 1 - line 48	1,6,7
	--	
X	US 3852755 A (G.A. WORKS ET AL.), 3 December 1974 (03.12.74), column 1, line 55 - column 2, line 26	1,6,7
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Information on patent family members

27/07/98

International application No.

PCT/IB 98/00218

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